8. CONTAMINATED SOIL SITES ARA-01, ARA-12, ARA-23, ARA-25, AND PBF-16

Remedial action is required for five contaminated soil sites: the ARA-I Chemical Evaporation Pond (ARA-01), the ARA-III Radioactive Waste Leach Pond (ARA-12), ARA-I and ARA-II Radiologically Contaminated Soils (ARA-23), ARA-I Soils Beneath the ARA-626 Hot Cells (ARA-25), and the SPERT-II Leach Pond (PBF-16). Though risks for the five contaminated soil sites were analyzed individually, they were considered collectively for the analysis of remedial alternatives. Therefore, Sections 8.1 through 8.5 each address a single site, including a summary of the site investigations, nature and extent of contamination, and baseline risk estimates. Subsequent sections present the analysis of alternatives for the entire group. Remedial action objectives, remedial alternatives, and the selected remedy are presented. More detailed information about the contaminated soil sites can be found in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999).

8.1 Site ARA-01: ARA-I Chemical Evaporation Pond

The ARA-01 Chemical Evaporation Pond will be remediated to address the risk to human and ecological receptors posed by contaminated soil. Site investigations, the nature and extent of contamination, and a summary of site risks are presented below. More detailed information about the evaporation pond can be found in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999).

The ARA-01 site is a shallow, unlined surface impoundment, roughly 30 × 90 m (100 × 300 ft) in size, that was used to dispose of laboratory wastewater from the ARA-I Shop and Maintenance Building (ARA-627). Located southeast of ARA-I, the pond was constructed in 1970 by excavating soil to create a shallow topographic depression. Basalt outcrops are present within and immediately adjacent to the pond. The subsurface immediately beneath the pond consists of fracture and rubble zones. No interbed was found within the first 36 m (118 ft).

From 1970 to 1988, the pond received process discharges that contained small quantities of radioactive substances, acids, bases, and volatile organic compounds. Since 1988, the pond has been dry except during spring runoff and heavy precipitation. Aerial photographs of ARA-01 before and after the D&D of the ARA-I facility are shown in Figure 10.

8.1.1 Site Investigations

The ARA-01 Chemical Evaporation Pond was identified as an RI/FS site in the FFA/CO (DOE-ID 1991). The ARA-01 RI/FS (Stanisich et al. 1992) considered data from 1982 sampling and from additional samples collected in 1990 to provide data for the ARA-01 BRA. To determine local background concentrations for metals, 10 additional samples were collected south of the pond in an area unaffected by ARA activities. The combined data from the samples collected from the pond included concentrations of volatile organic compounds, arsenic, chromium(III), chromium(VI), cadmium, beryllium, Cs-134, Cs-137, Co-60, Pu-239, and U-234 in excess of background values (Stanisich et al. 1992). The samples with the highest contaminant concentrations were collected adjacent to the pond inlet.

The ARA-01 BRA (Stanisich et al. 1992) indicated that risks associated with surface exposure pathways were all below levels of concern. However, data were not adequate to analyze the risks associated with the groundwater exposure pathways. Therefore, the ARA-01 ROD (DOE-ID 1992a) documented the conclusion that remedial action is not necessary to protect human health and the environment from surface pathway exposures, and stipulated that additional evaluation of subsurface

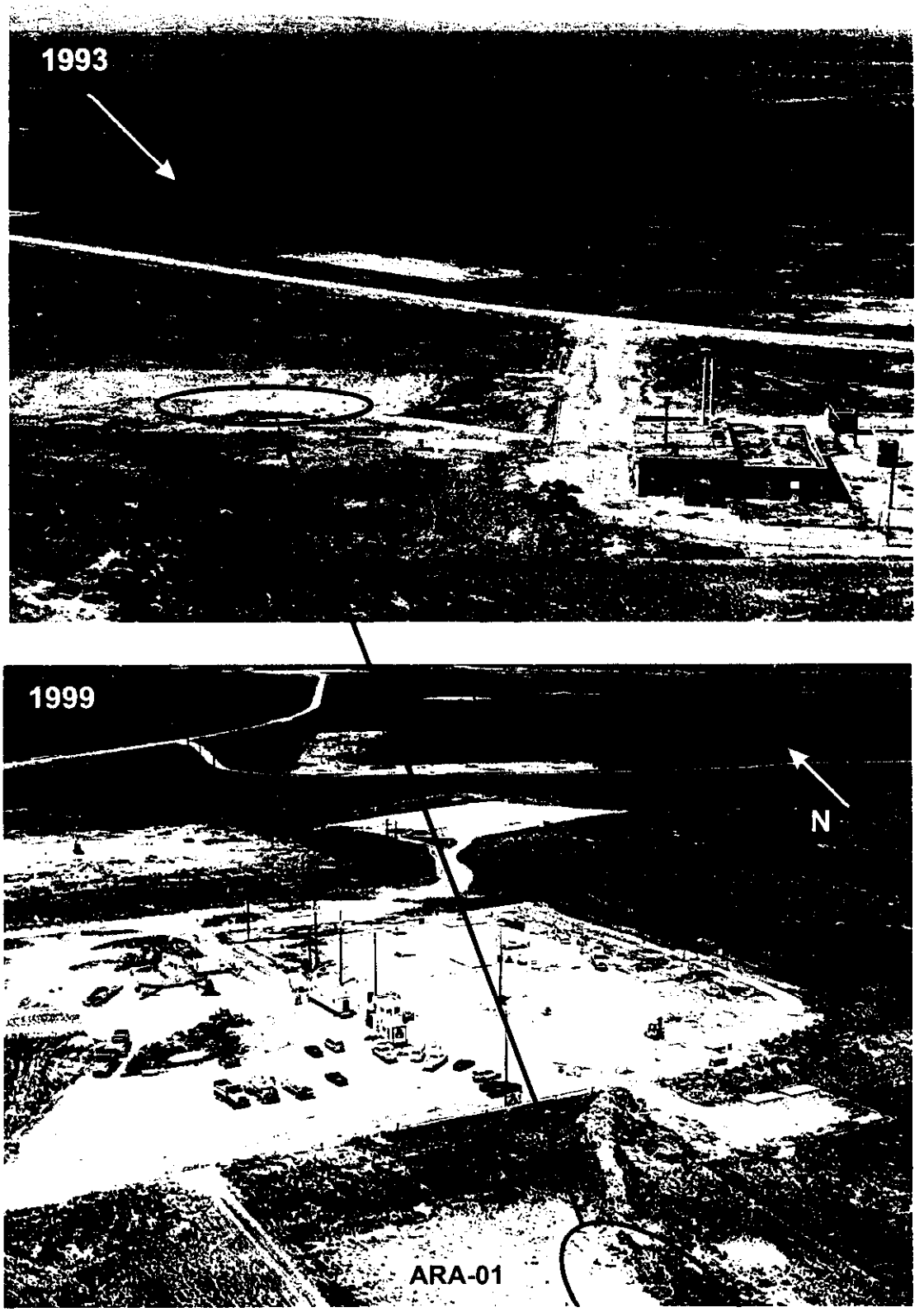

Figure 10. Aerial photographs of Site ARA-01 before and after the decontamination and dismantlement of the ARA-I facility.

conditions and the groundwater pathway would be conducted in a future investigation (e.g., the WAG 5 Comprehensive RI/FS).

Consequently, a data need was identified in the WAG 5 Work Plan (DOE-ID 1997a) to determine the vertical extent of contamination. To meet this data need, two boreholes were drilled. Biased locations were selected for the boreholes (i.e., the location of the highest previously detected Cs-137 concentration and in the area of the pond with the lowest elevation) to maximize the likelihood of detecting the highest contaminant concentrations present in the pond. The boreholes were drilled to depths of 28.7 m (94 ft) and 36 m (118 ft) without encountering an interbed. At 36 m (118 ft), the drill string and bit became stuck in the second borehole and only part of the drill string, the top 10.7 m (35 ft), was recovered. Therefore, no subsurface samples were obtained from either borehole (Wilson-Lopez 1997). However, in situ gamma and beta surveys were completed. The gamma measurements were collected from the surface to the bottom of each borehole. An average Cs-137 concentration of 0.38 ± 0.03 pCi/g to a depth of 0.9 m (3 ft) below ground surface was detected, with no gamma concentrations detected below 0.9 m (3 ft). No other gamma-emitting radionuclides were detected. The in situ beta measurements were collected starting at a depth of 1.2 m (4 ft) from the surface (i.e., below the well casing) and continuing to the bottom of each borehole. No beta emitters (e.g., Sr-90) were detected above background concentrations in either borehole (Giles 1997).

A second task identified in the Work Plan (DOE-ID 1997a) was to collect samples for analysis of alpha emitters (e.g., Pu-239 and U-234) and Sr-90. A grid was established over the site on 3-m (10-ft) centers. Nineteen locations were selected at random from the grid, and samples were collected from two depths per location for a total of 38 samples. The complete data sets for the samples collected in 1997 are given in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999, Appendix E).

8.1.2 Nature and Extent of Contamination

The location of ARA-01 relative to ARA-I, soil profiles for the COCs, and the source volume used in the risk assessment are illustrated in Figure 11. The figure shows the contaminant concentrations at depths below the surface. Surface sediments are shallow at ARA-01, with a maximum thickness of 1 m (3.5 ft) and an average thickness of 0.5 (1.5 ft). A constant surface soil thickness of 0.6 m (2 ft) was used in the risk assessment. Vertically, the contamination is limited to the surficial sediments, as evidenced by the results of the borehole logging and the analysis of surface soil samples. Laterally, the contamination is contained within the bounds of the pond. The maximum detected arsenic concentration is 25.8 mg/kg compared to a background value of 5.8 mg/kg. For selenium, the maximum detected and background concentrations are 27.7 mg/kg and 0.22 mg/kg, respectively. Thallium was detected at a maximum concentration of 59.2 mg/kg, and the INEEL background value is 0.43 mg/kg. Background values for all three contaminants were taken from Rood, Harris, and White (1996).

8.1.3 Summary of Site Risks

The 1997 samples yielded concentrations of Am-241, Cs-137, Sr-90, U-235, Pu-238, Pu-239/240, Ra-226, arsenic, lead, and thallium in excess of contaminant screening levels for human health, and concentrations of antimony, arsenic, cadmium, chromium, copper, lead, selenium, silver, thallium, vanadium, and zinc above screening levels for the ecological risk assessment. The results of the human health and ecological risk assessments are given below.

8.1.3.1 Human Health Risk Assessment Summary. Arsenic is identified as a COC based on human health risk estimates. A summary of the information about the human health COC in soil at ARA-01 is given in Table 8.

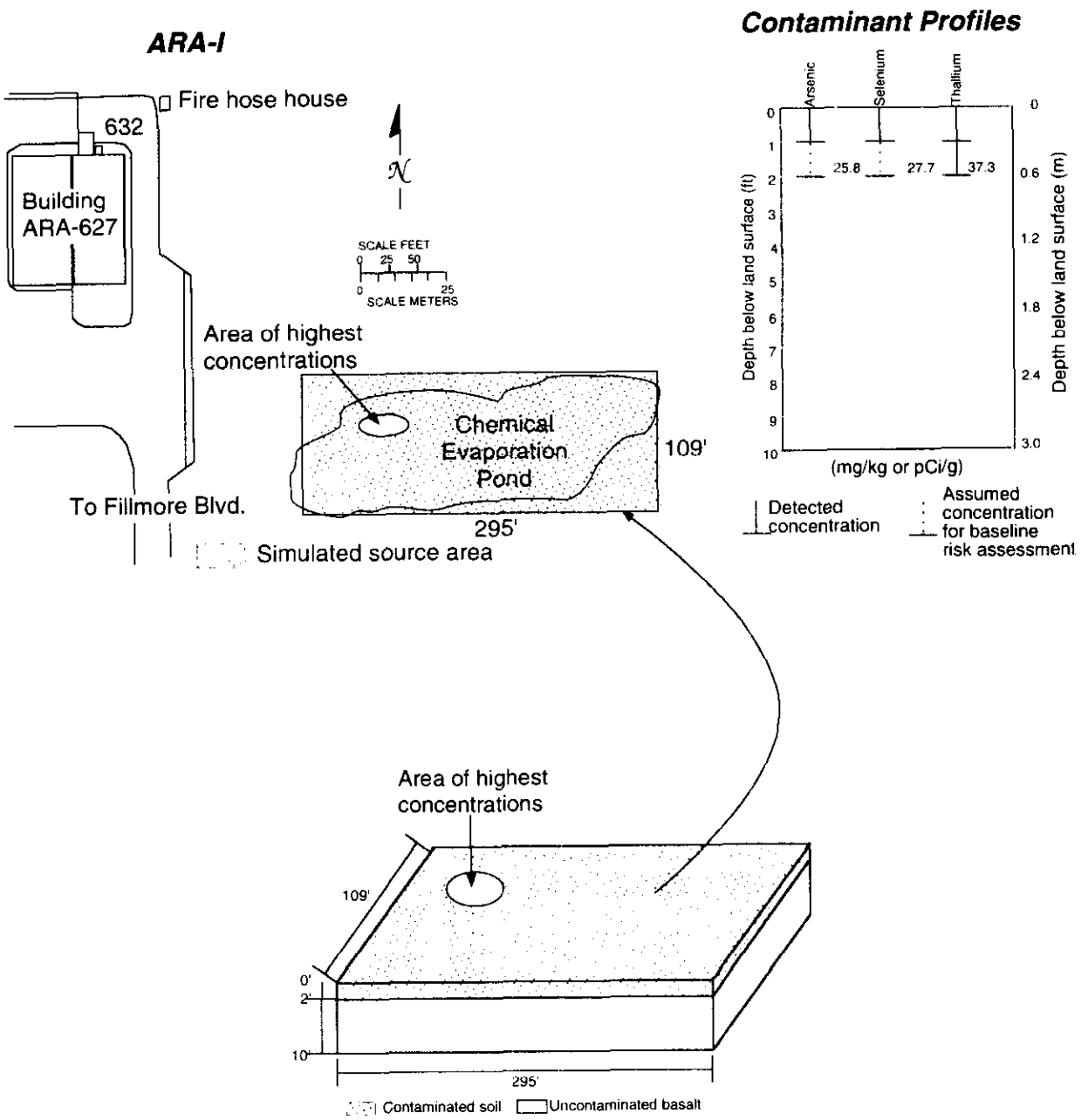

Figure 11. Site ARA-01, ARA-I Chemical Evaporation Pond.

Table 8. Soil concentrations for the contaminant of concern at ARA-01.

Contaminant of Concern	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Frequency of Detection	Background Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	Statistical Measure
Arsenic	11	25.8	7/35	5.8[a]	22.1	UCL[b]

a. The background value for composited samples is from Rood, Harris, and White (1996).

b. The UCL is the 95% upper confidence limit on the mean soil concentration.

The total risk for all pathways for the current occupational scenario is 1E-04 (1 in 10,000), primarily from exposure to arsenic. The noncarcinogenic hazard index for the current occupational scenario is less than 1.0.

The total estimated risk for all pathways for the 100-year future residential scenario is 2E-04 (2 in 10,000) from arsenic. The noncarcinogenic hazard index of 1.0 for the future residential scenario is from arsenic.

The total estimated risk for all pathways for the 100-year future occupational scenario is less than 1E-04, and the noncarcinogenic hazard index for the future occupational scenario is less than 1.0.

8.1.3.2 Ecological Risk Assessment Summary. Selenium and thallium were identified as COCs for ARA-01 based on HQs for ecological receptors. A summary of the information about the ecological COCs in soil at ARA-01 is given in Table 9.

The HQs for exposure to selenium in surface soil at ARA-01 range from 2 for avian insectivores (AV210) and avian omnivores (AV422) to 300 for mammalian insectivores (M222). Mammalian herbivores (including the pygmy rabbit) also have HQs exceeding 1.0.

The HQs for exposure to thallium in surface and subsurface soil range from 2 for avian omnivores (AV422) to a maximum of 300 for mammalian insectivores (M222). The bat species and pygmy rabbit, both classified by the State of Idaho as species of special concern, also are potentially at risk from exposure to thallium in soil at this site.

Table 9. Soil concentrations for the ecological contaminants of concern at ARA-01.

Contaminant of Concern	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Frequency of Detection	Background Concentration (mg/kg)[a]	Exposure Point Concentration (mg/kg)	Statistical Measure[b]
Selenium	14.8	27.7	7/35	0.22	27.7	Maximum
Thallium	13.5	59.2	21/35	0.43	37.3	UCL

a. The background value for composited samples is from Rood, Harris, and White (1996).

b. The UCL is the 95% upper confidence limit on the mean soil concentration. When the number of samples was too small for statistical analysis, the maximum detected concentration was used for the exposure point concentration.

8.2 Site ARA-12: ARA-III Radioactive Waste Leach Pond

Remedial action is required for the ARA-12 Radioactive Waste Leach Pond to address the risk to human and ecological receptors posed by contaminated soil. Site investigations, the nature and extent of contamination, and a summary of site risks are presented below. More detailed information about the pond can be found in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999).

The ARA-12 site is an unlined surface impoundment with approximate dimensions of 115 × 50 m (370 × 150 ft). The pond was constructed in a natural depression west of ARA-III to dispose of low-level liquid waste from reactor research operations. Liquid waste was stored temporarily in tanks, then transferred to the leach pond via an underground pipe. Effluent contained low-level radioactive material. A second, separate discharge line originated in an uncontaminated water storage tank. The pond also received facility runoff through a culvert. The ARA-III facility was an active reactor research facility from about 1959 to 1965. From 1966 to 1987, activities at ARA-III were limited to component and instrumentation testing, instrumentation development and fabrication, and chemical research. Waste associated with these activities was not disposed of in the leach pond, and the only discharges to the pond during this period were from the water storage tank and facility runoff. The facility was shut down in 1987, leaving the pond dry except during spring runoff and heavy precipitation. In 1991, the culvert was plugged in preparation for D&D operations at ARA-III, and in 1993, the tanks and waste lines to the leach pond were removed. Aerial photographs of Site ARA-12 before and after the D&D of the ARA-III facility are shown in Figure 12.

8.2.1 Site Investigations

A Track 2 evaluation was initiated in 1993 and completed in 1994 (Pickett et al. 1994). Radiological and topographical surveys were performed, and soil samples were collected and analyzed. The outer dimensions of the pond were estimated at 115 × 50 m (377 × 164 ft). A smaller area of approximately 21 × 61 m (69 × 200 ft), which received the majority of the wastewater, still contained remnants of enhanced vegetation. The 1993 data were combined with historical information to evaluate nonintrusive (i.e., the construction of a basement is not considered) 100-year future residential and current occupational exposure scenarios defined in the Track 2 guidance (DOE-ID 1994). Future residential intrusive and future occupational scenarios were not assessed. The evaluated contaminants included Ag-108m, Cs-137, U-235, Am-241, Co-60, Pu-238, U-234, chromium, cadmium, lead, and Aroclor-1254. A total risk of 2E-03 (2 in 1,000), primarily from direct exposure to Ag-108m, Cs-137, and U-238, was estimated for the 100-year future residential nonintrusion scenario.

The ARA-12 surface soil was surveyed in 1997 with the global positioning radiometric scanner (GPRS). Elevated gamma levels were detected within ARA-12 and an area just west of the site boundary. Because the area is debris-filled and nearly inaccessible to the GPRS, a germanium spectrometer (Ge-spectrometer) was deployed to determine the extent of the contamination. The data from the GPRS were analyzed by incorporating the assumption that Cs-137 was the source of elevated gamma levels. Based on this assumption, concentrations greater than 45 pCi/g were indicated. However, subsequent analytical results from soil samples collected in these areas indicated that Ag-108m is the source of the elevated gamma levels (Giles 1999b).

8.2.2 Nature and Extent of Contamination

The location of ARA-12 relative to ARA-III, soil profiles for the COCs, and the source volume used in the risk assessment are illustrated in Figure 13. Contaminant concentrations were detected throughout most of the soil profile to a depth of 5 to 7 ft. The highest surface soil gamma levels detected

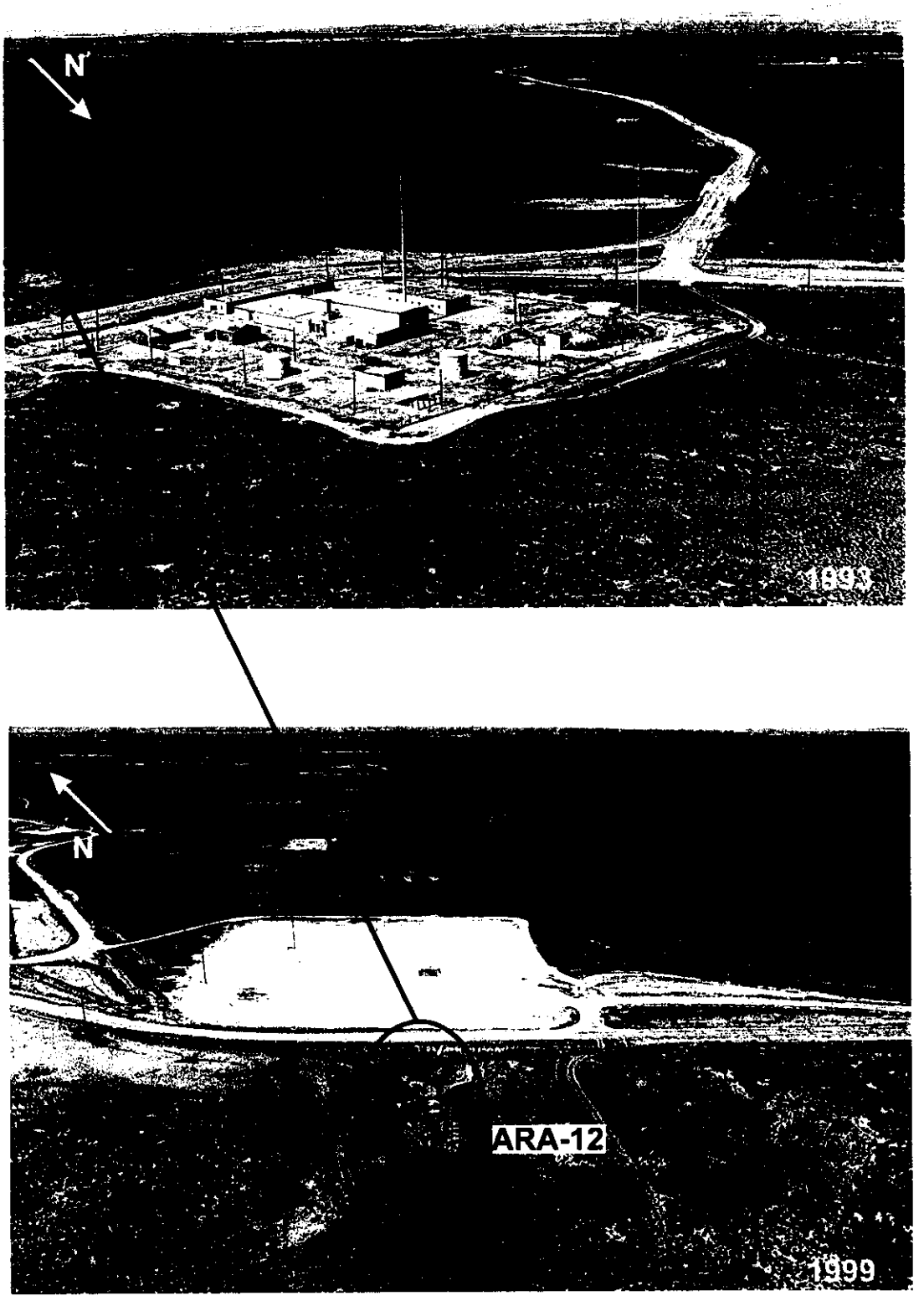

Figure 12. Aerial photographs of Site ARA-12 before and after the decontamination and dismantlement of the ARA-III facility.

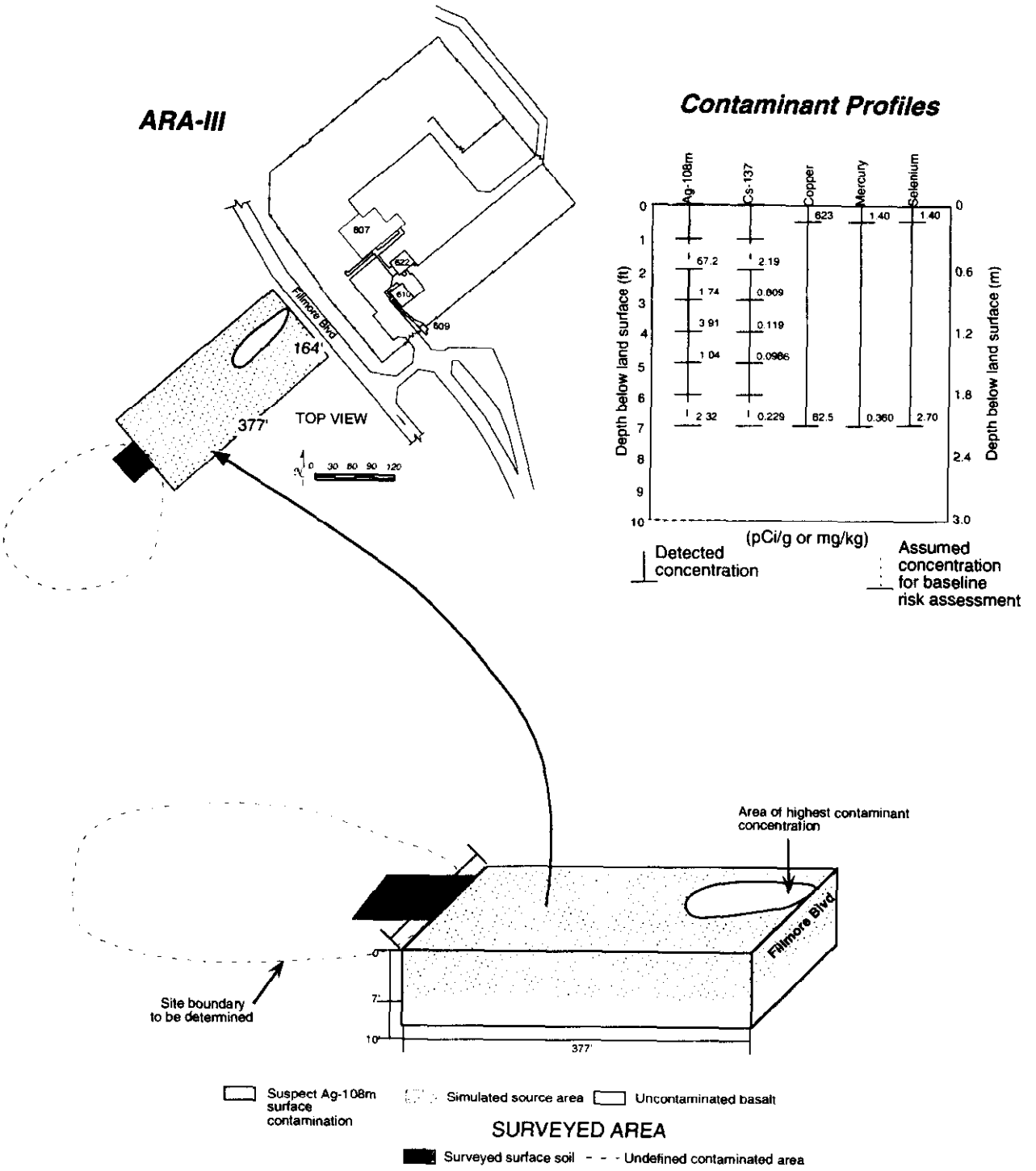

Figure 13. Site ARA-12, ARA-III Radioactive Waste Leach Pond.

with the GPRS are outside of the pond boundary at the southwest corner. This area will be remediated as a part of ARA-12.

The maximum detected concentration of Ag-108m is 67.2 pCi/g. Because Ag-108m is not naturally occurring, any detected concentration is above an assumed background value of zero. The maximum copper concentration at ARA-12 is 623 mg/kg in surface soil compared to the INEEL background concentration of 22 mg/kg (Rood, Harris, and White 1996). Mercury was detected at 1.40 mg/kg in surface soil at ARA-12, which is two orders of magnitude higher than the INEEL background soil concentration of 0.05 mg/kg (Rood, Harris, and White 1996). The selenium concentration in soil at ARA-12 is 1.37 mg/kg, and the INEEL background concentration is 0.22 mg/kg (Rood, Harris, and White 1996).

8.2.3 Summary of Site Risks

The ARA-12 site was retained for quantitative risk analysis in the comprehensive RI/BRA to evaluate the human health risks from chromium, lead, manganese, Ag-108m, Am-241, Co-60, Cs-137, Pu-238, U-234, and U-238 and the ecological risks from arsenic, benzo(a)pyrene, cadmium, chromium, copper, lead, manganese, mercury, selenium, silver, and zinc (Holdren et al. 1999). The human health and ecological risk assessments are summarized below.

8.2.3.1 Human Health Risk Assessment. Silver-108m (Ag-108m) is identified as a COC for ARA-12 based on human health risk estimates (Holdren et al. 1999). A summary of the information about the human health COC in soil at ARA-12 is given in Table 10.

Table 10. Soil concentrations for the human health contaminant of concern at ARA-12.

Contaminant of Concern	Half-life (years)	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Frequency of Detection	Background Concentration (pCi/g)	Exposure Point Concentration (pCi/g)	Statistical Measure
Ag-108m	130[a]	0.23	67.2	17/17	0[b]	20.8	UCL[c]

a. The estimated half-life for Ag-108m was recently modified from 130 years, the value used in the baseline risk assessment (Holdren et al. 1999), to 418 years (Firestone and Shirley 1999).

b. Because Ag—108m is not naturally occurring and is not associated with fallout from historical atomic testing, the assumed background value is zero.

c. The UCL is the 95% upper confidence limit on the mean soil concentration.

Using the concentrations detected in the 1993 Track 2 investigation (Pickett et al. 1994), the total estimated risk for all pathways for the 100-year future residential scenario is 2E-03 (2 in 1,000). The primary contribution is 2E-03 (2 in 1,000) from Ag-108m. The noncarcinogenic hazard index for the future residential exposure is less than 1.0.

Risk for the 100-year future residential scenario also was evaluated using the data from the GPRS surface soil survey. The gamma levels were converted to concentrations using the assumption that Cs-137 was the source of the elevated gamma readings. Calculations produced an average Cs-137 concentration estimate of 47.4 pCi/g for ARA-12. Using this concentration, the estimated risk for external exposure to Cs-137 for the 100-year future residential scenario is 2E-04 (2 in 10,000). Therefore, Cs-137 was initially identified as a COC for ARA-12. Subsequently, however, results from confirmation samples indicated that Ag-108m is the source of the elevated gamma levels at ARA-12, not Cs-137 (Giles 1999b).

The total estimated risk for all pathways for the current occupational scenario is 1E-03 (1 in 1,000). The primary contributions are 1E-03 (1 in 1,000) from Ag-108m and 2E-04 (2 in 10,000) from Co-60. The noncarcinogenic hazard index for the current occupational exposure is less than 1.0.

The total estimated risk for all pathways for the 100-year occupational scenario is 6E-04 (6 in 10,000). The primary contribution is 6E-04 (6 in 10,000) from Ag-108m. The noncarcinogenic hazard index for the future occupational exposure is less than 1.0.

8.2.3.2 Ecological Risk Assessment. Copper, mercury, and selenium were identified as COCs for ARA-12 based on HQs for ecological receptors. A summary of the information about the ecological COCs in soil at ARA-12 is given in Table 11.

The HQs for copper at ARA-12 range from 1 to 300 for avian insectivores and mammals including the pygmy rabbit and bats. The HQs for mercury range from 1 to 90 for plants and for avian herbivores (AV121 and 122) and mammals including the pygmy rabbit and bats. The HQs for selenium range from 1 to 30 for avian insectivores (AV221, 222, and 222A) and mammalian species including the three bat species of special concern.

Table 11. Soil concentrations for the ecological contaminants of concern at ARA-12.

Contaminant of Concern	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Frequency of Detection	Background Concentration[a] (mg/kg)	Exposure Point Concentration (mg/kg)	Statistical Measure[b]
Copper	12.9	623	24/24	22	62.5	UCL
Mercury	0.24	1.4	7/24	0.05	0.36	UCL
Selenium	0.25	2.7	6/23	0.22	2.7	Maximum

a. The background value for composited samples is from Rood, Harris, and White (1996).

b. The UCL is the 95% upper confidence limit on the mean soil concentration. When the number of samples was too small for statistical analysis, the maximum detected concentration was used for the exposure point concentration.

8.3 Site ARA-23: Radiologically Contaminated Surface Soils and Subsurface Structures Associated with ARA-I and ARA-II

Remedial action is required for the ARA-23 radiologically contaminated soils to address the risk to human health posed by contaminated soil. Site investigations, the nature and extent of contamination, and a summary of site risks are presented below. More detailed information about the site can be found in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999).

The ARA-23 site is a 17-ha (42-acre) windblown contamination area surrounding ARA-I and –II. The site also contains subsurface structures remaining after D&D within the ARA-I and ARA-II facilities. Soil was radiologically contaminated by the 1961 SL-1 accident and subsequent cleanup. Minor amounts of contamination may have been added by other ARA operations. Over time, winds dispersed the contamination over an area roughly 100 hectares (240 acres) in size, but soil concentrations over most of the area are significantly less than risk-based remediation goals. The long axis of the roughly oval-shaped site is consistent with the generally southwest-to-southeast winds common at the INEEL. Aerial photographs of the ARA-I and ARA-II facilities before and after D&D are given in Figure 14.

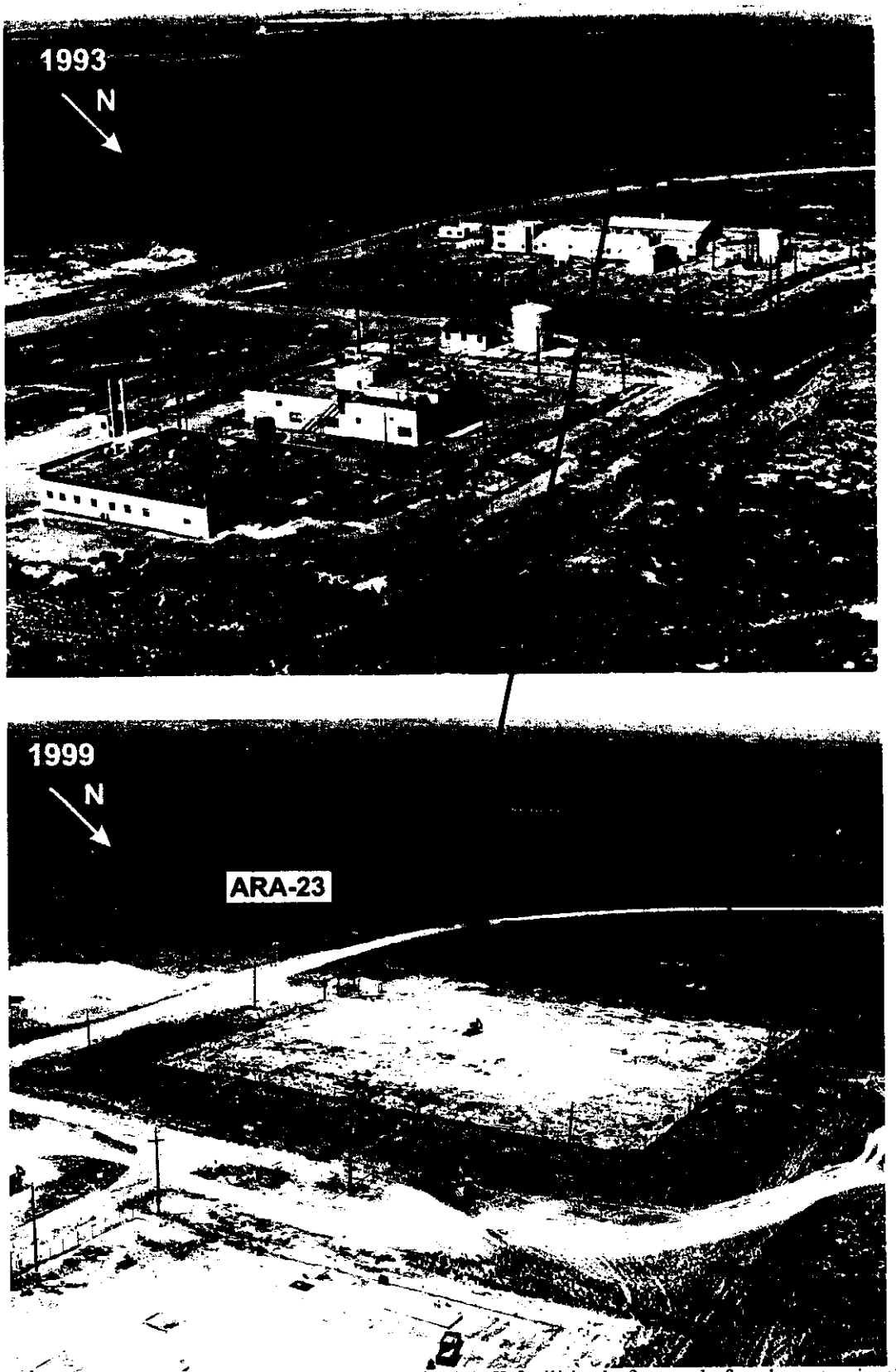

Figure 14. Aerial photographs of the ARA-I and ARA-II facilities before and after decontamination and dismantlement, including a portion of Site ARA-23.

8.3.1 Site Investigations

The windblown contamination site was originally defined as the subsurface structures (e.g., reactor building foundation and underground utilities) within the ARA-I and ARA-II facility fences and all radiologically contaminated surface soil in the area defined by an aerial survey isopleth (Jorgensen 1995). Site ARA-06, the SL-1 Burial Ground, was excluded from ARA-23. A Track 1 investigation was initiated for ARA-23 in 1993 but was not finalized because the site was reassigned to OU 10-06 for evaluation. The OU 10-06 evaluation, which excluded the areas within the ARA-I and ARA-II facility fences, was only partially completed before ARA-23 was reassigned to WAG 5 for final disposition.

As documented in the ROD for the SL-1 Burial Ground (DOE-ID 1996b), the boundary of ARA-06 was expanded outward from the SL-1 Burial Ground perimeter fence to include approximately 40% of ARA-23. Based on dose equivalent rates (Jorgensen 1995), no unacceptable risks were identified for this area and remedial actions specified in the SL-1 ROD (DOE-ID 1996b) excluded all soil outside of the SL-1 Burial Ground fence.

The data gaps identified in the WAG 5 Work Plan (DOE-ID 1997a) comprised the horizontal and vertical extent of Cs-137 in the windblown soil area and the presence of other radionuclides such as Co-60, Eu-152, Eu-154, Sr-90, and uranium isotopes. To fill the data gaps identified in the Work Plan, historical sample data from surface soil at ARA-23 were interpolated (i.e., kriged) to generate concentration isopleths. Verification samples were collected at 19 approximately equally spaced locations along the 10-pCi/g isopleth for Cs-137 at depths of 0 to 15 cm (0 to 6 in.) and 15 cm to 0.6 m (6 in. to 2 ft) for a total of 38 samples. The analytical results are presented in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999, Appendix E).

In addition, a surface gamma-radiation survey using a vehicle-mounted GPRS and a hand-held Ge-spectrometer (Josten 1997) was conducted over the entire windblown contamination site (i.e., ARA-23 and ARA-06) to determine the approximate lateral extent and concentrations of Cs-137. The GPRS was used to survey areas accessible by vehicle. The Ge-spectrometer was used for areas requiring walk-over survey techniques. Approximately 69,000 in situ gamma-radiation measurements were collected with the GPRS. The highest value recorded at the site was 117,961 counts per second. Eighty-eight measurements were taken with the Ge-spectrometer at a rocky, debris-filled area that was inaccessible to the GPRS, and 14 additional measurements were collected at a selected set of calibration points. Data from the GPRS survey and the Ge-spectrometer were combined into a common database, and maps were compiled showing position, data-point distribution, bulk gamma radiation, and Cs-137 concentrations.

Though a conclusion of the SL-1 investigation was that surface soil within the Burial Ground fence and in the surrounding area were not contaminated (DOE-ID 1996b), the GPRS survey detected elevated gamma levels within these areas. Therefore, the entire region with elevated gamma levels was evaluated in the BRA for ARA-23.

8.3.2 Nature and Extent of Contamination

The location of ARA-23 relative to ARA-I and ARA-II; the soil profile for Cs-137, the COC; and the source volume used in the risk assessment are illustrated in Figure 15. Contaminant concentrations were detected throughout most of the soil profile to a depth of 0.6 m (2 ft). The Cs-137 concentrations measured by the GPRS at ARA-23 are illustrated in Figure 16.

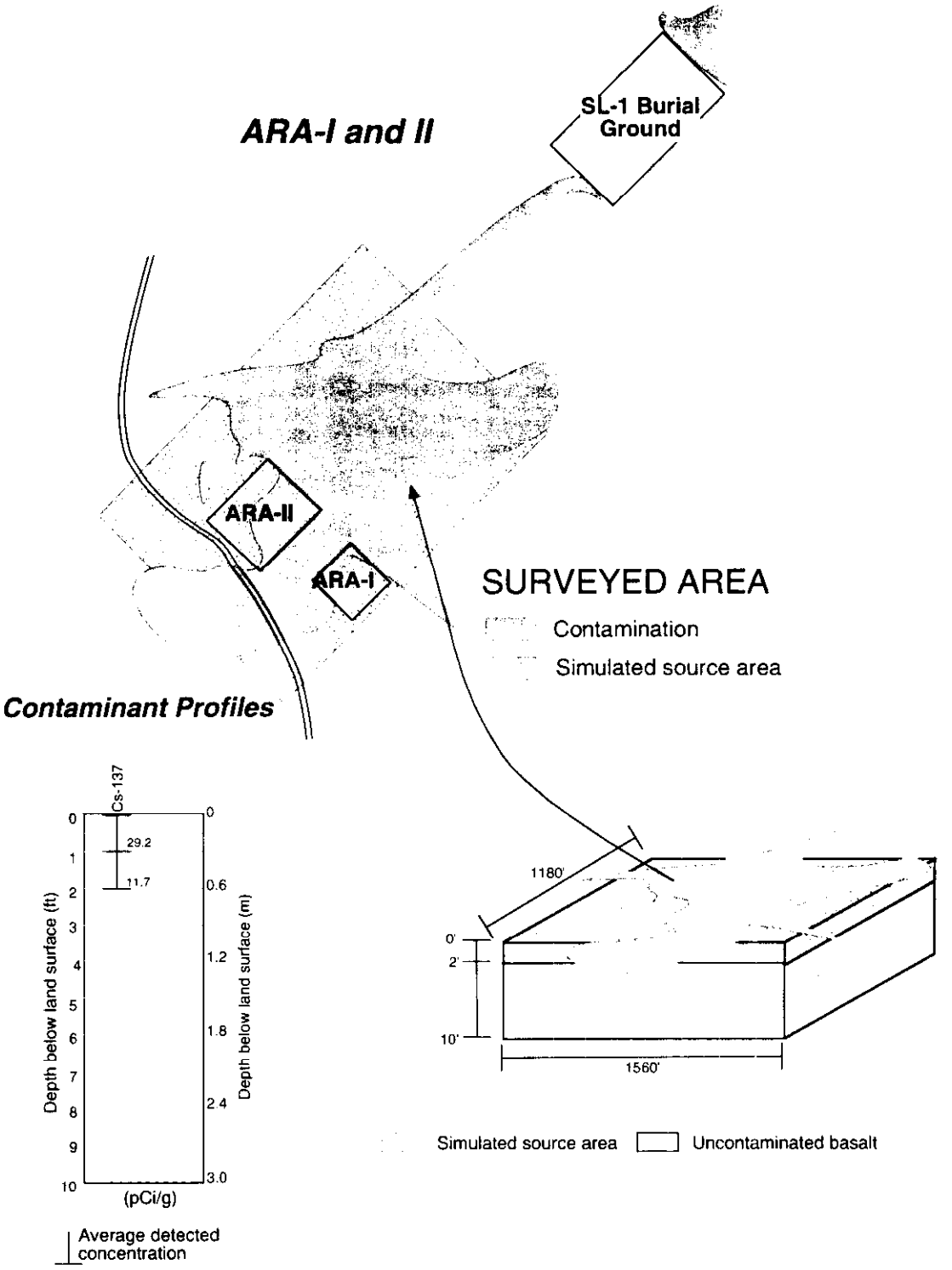

Figure 15 . Site ARA-23, ARA-I and -II radiologically contaminated soils and subsurface structures.

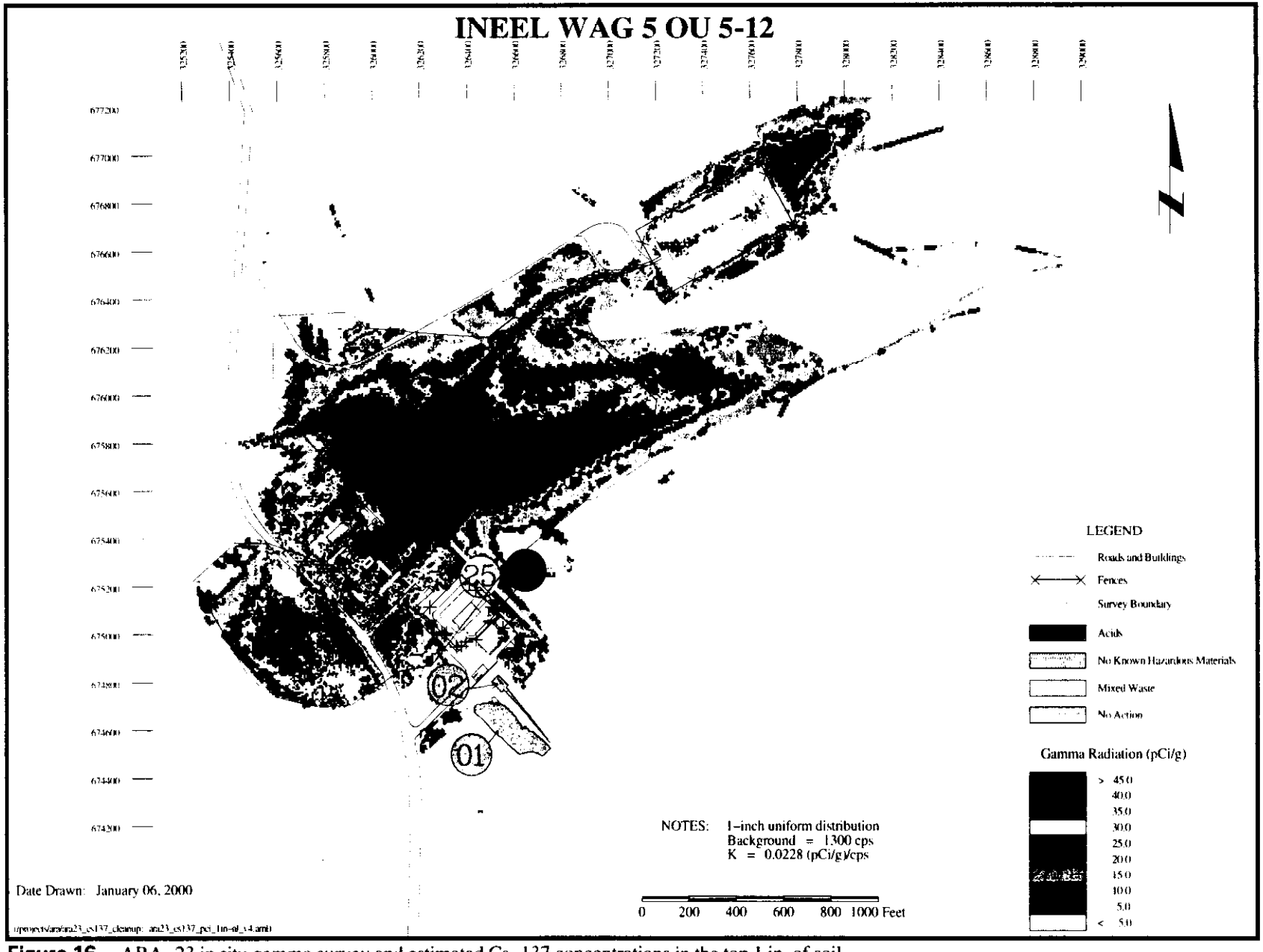

Figure 16. ARA-23 in situ gamma survey and estimated Cs-137 concentrations in the top 1 in. of soil.

8.3.3 Summary of Site Risks

The ARA-23 site was retained for quantitative risk assessment in the comprehensive BRA to evaluate the human health risk potential from Am-241, Cs-137, Ra-226, Sr-90, Th-230, and U-235 detected in the soil. The site also was retained for qualitative risk evaluation of Cs-137 data obtained with the GPRS. Because ARA-23 encompasses the ARA-I and ARA-II facilities and the SL-1 Burial Ground, 15 other sites (i.e., ARA-01, -02, -03, -04, -05, -06, -07, -08, -09, -10, -11, -16, -17, -19, and -25) fall within the boundaries of the windblown contamination area as originally defined. Several of these sites were retained for quantitative analysis in the RI/BRA (Holdren et al. 1999). Others were eliminated from further evaluation. However, residual soil contamination at these 15 sites probably was generated by the same sources as the ARA-23 contamination. Therefore, all residual soil contamination in ARA-23 not specifically addressed for another individual site will be addressed as part of the RD/RA with ARA-23.

8.3.3.1 Human Health Risk Assessment. Cesium-137 was identified as a COC for ARA-23 based on human health risk estimates. A summary of the information about the COC in soil at ARA-23 is given in Table 12. The noncarcinogenic hazard index is not applicable to radionuclides because all radionuclides are classified as probable carcinogens. The carcinogenic risk estimates are presented below for the evaluated exposure scenarios.

Table 12. Soil concentrations for the contaminant of concern at ARA-23.

Contaminant of Concern	Half-life (years)	Minimum Concentration (pCi/g)	Maximum Concentration (pCi/g)	Frequency of Detection	Background Concentration (pCi/g)	Exposure Point Concentration (pCi/g)	Statistical Measure
Cs-137	30	0.27	2,140	175/176	0.82[a]	88.5[b]	Average

a. The background value for composited samples is from Rood, Harris, and White (1996).

b. The surface survey data were used to calculate the exposure point concentration for the 100-year future residential scenario.

Based only on the analytical results, the estimated total risk for all pathways for the 100-year future residential scenario is 1E-04 (1 in 10,000). Cesium-137 is the primary contributor. However, risks are probably underestimated because the samples are not representative of the highest contaminant concentrations at the site.

The GPRS data were used to estimate external exposure risks for the 100-year future residential scenario and to support the decision to remediate this site. Calculations produced an average Cs-137 concentration estimate of 88.5 pCi/g for ARA-23. The estimated risk from the external exposure pathway only for the 100-year future residential scenario is 5E-04 (5 in 10,000). Risk is also underestimated based on the GPRS data because the measurements to determine background were included in the calculations of the average concentration and because only one exposure pathway was evaluated. Because the risk is probably underestimated at the 10^{-4} order of magnitude, the site was identified for remediation.

The estimated total risk based on sampling for all pathways for the current occupational scenario is less than 1E-04. Occupational scenario risks would be much higher based on the GPRS data.

The estimated total risk based on sampling for all pathways for the 100-year occupational scenario is less than 1E-04. Occupational scenario risks would be much higher based on the GPRS data.

8.3.3.2 Ecological Risk Assessment. The ARA-23 site was screened from evaluation in the ERA because the only contaminants above background levels are radionuclides. As discussed in Section 7.2, all radionuclides were eliminated in the contaminant screening for the ERA.

8.4 Site ARA-25: ARA-I Soil Beneath the ARA-626 Hot Cells

Remedial action is required for the ARA-25 Soil Beneath the ARA-626 Hot Cells to address the risk to human and ecological receptors posed by contaminated soil. Site investigations, the nature and extent of contamination, and a summary of site risks are presented below. More detailed information about the site can be found in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999).

The ARA-25 site comprises contaminated soil that was discovered beneath the ARA-626 Hot Cells during the D&D of the ARA-I facility in 1998. The contamination was found near the hot cell floor drains. The contaminated area immediately around the drains measures approximately 2.4× 3.7 m (8 × 12 ft). However, other isolated hot spots beneath the building also were discovered. Therefore, a cumulative size of 4.9 × 7.3 m (16 × 24 ft) was estimated for the site.

The ARA-I hot cells were constructed in 1959 and used until the facility was shut down in 1988. In addition to liquid radioactive waste such as wash water from the ARA-I hot cells, chemicals from materials testing and research and metal-etching processes were used at the facility. Stainless steel piping connected the floor drains to the ARA-729 Radionuclide Tank (Site ARA-16), which contains PCB-contaminated, RCRA F-listed mixed waste (40 CFR 261, Subpart D) and transuranic radionuclides. The pipes are included in the remediation of Site ARA-16 and are not a component of the ARA-25 site. Aerial photographs of Site ARA-25 before and after the D&D of ARA-I are shown in Figure 17.

8.4.1 Site Investigations

As part of the ongoing D&D activities at ARA I, radiologically contaminated concrete floor slabs were cut out of the ARA-626 Hot Cells. Because the concrete was poured directly on the soil, the undersides of the slabs (about 15 cm [6 in.] thick) were covered completely with soil. The soil that sloughed off the underside of the concrete slabs and the rebar protruding from the concrete were surveyed for radioactivity. Initial contamination levels of 50,000 disintegrations per minute were identified.

In 1998, the hot cells were removed and the concrete floor slab and underlying soil were sampled. Three soil samples were collected in the area of the floor drains, and three samples were taken of the concrete. The fixed contamination on the concrete was not evaluated for risk, but will be removed as part of the remediation of WAG 5. After sampling, a fixative was applied to the soil exposed under the concrete slabs and the roof of the hot cell building was placed on the ground over the area for shielding. Results from the analysis of the soil samples demonstrate that the contaminated soil at ARA-25 is not classified as RCRA-hazardous waste. Through review of process knowledge and analytical data, DOE, EPA, and IDHW have determined that ARA-25 soil is not classified as hazardous waste (Rose 1999).

8.4.2 Nature and Extent of Contamination

The soil profiles for the COCs and the source volume used in the risk assessment and the location of ARA-25 relative to ARA-I are illustrated in Figure 18. Because sampling was limited to the surface soil near the drains, the risk assessment incorporated the assumption that the maximum detected concentrations extend from the surface down to the basalt interface at a depth of 1.5 m (5 ft) over a total area of 4.9 × 7.3 m (24 × 16 ft).

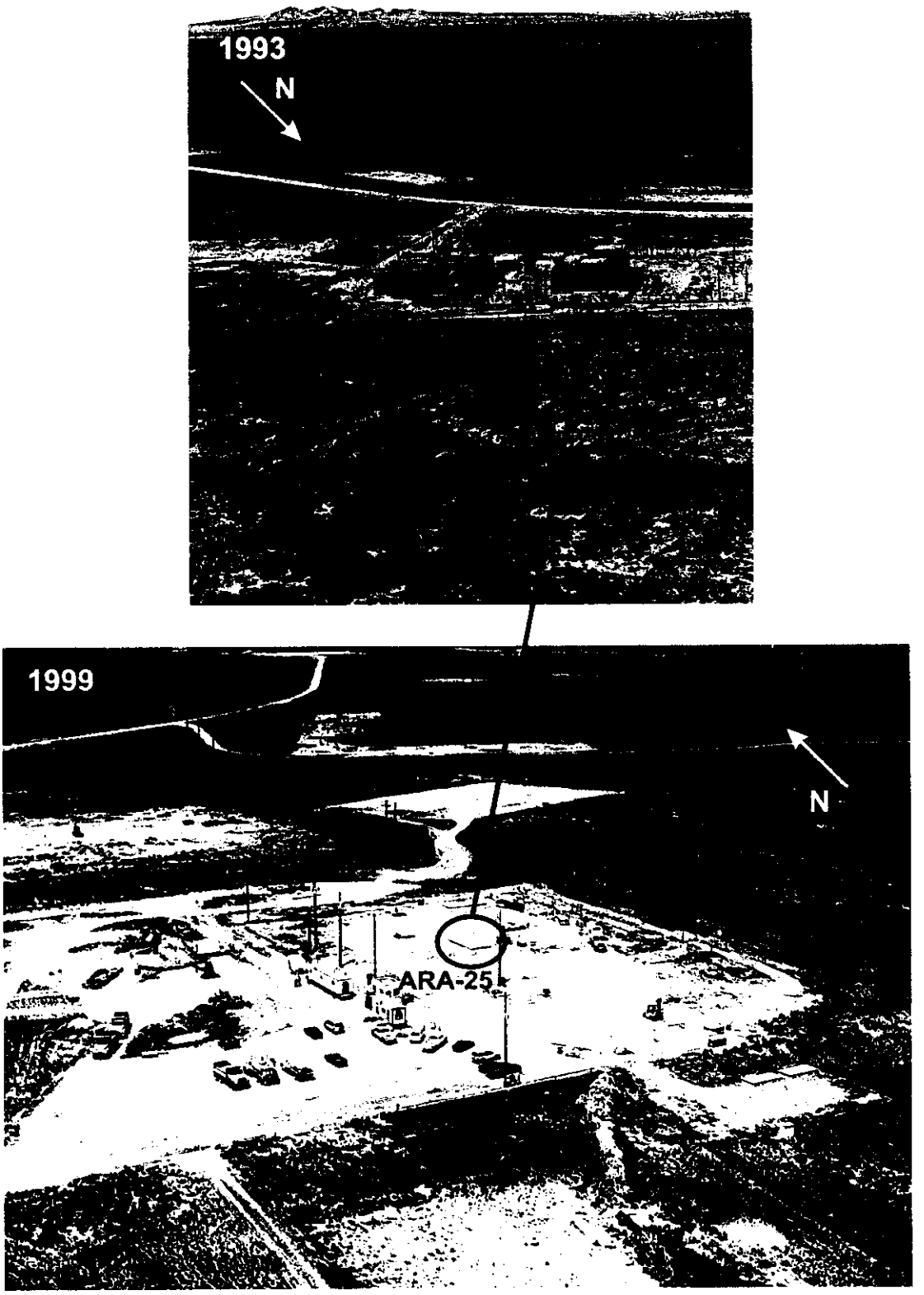

Figure 17. Aerial photographs of Site ARA-25 before and after the decontamination and dismantlement of the ARA-I facility.

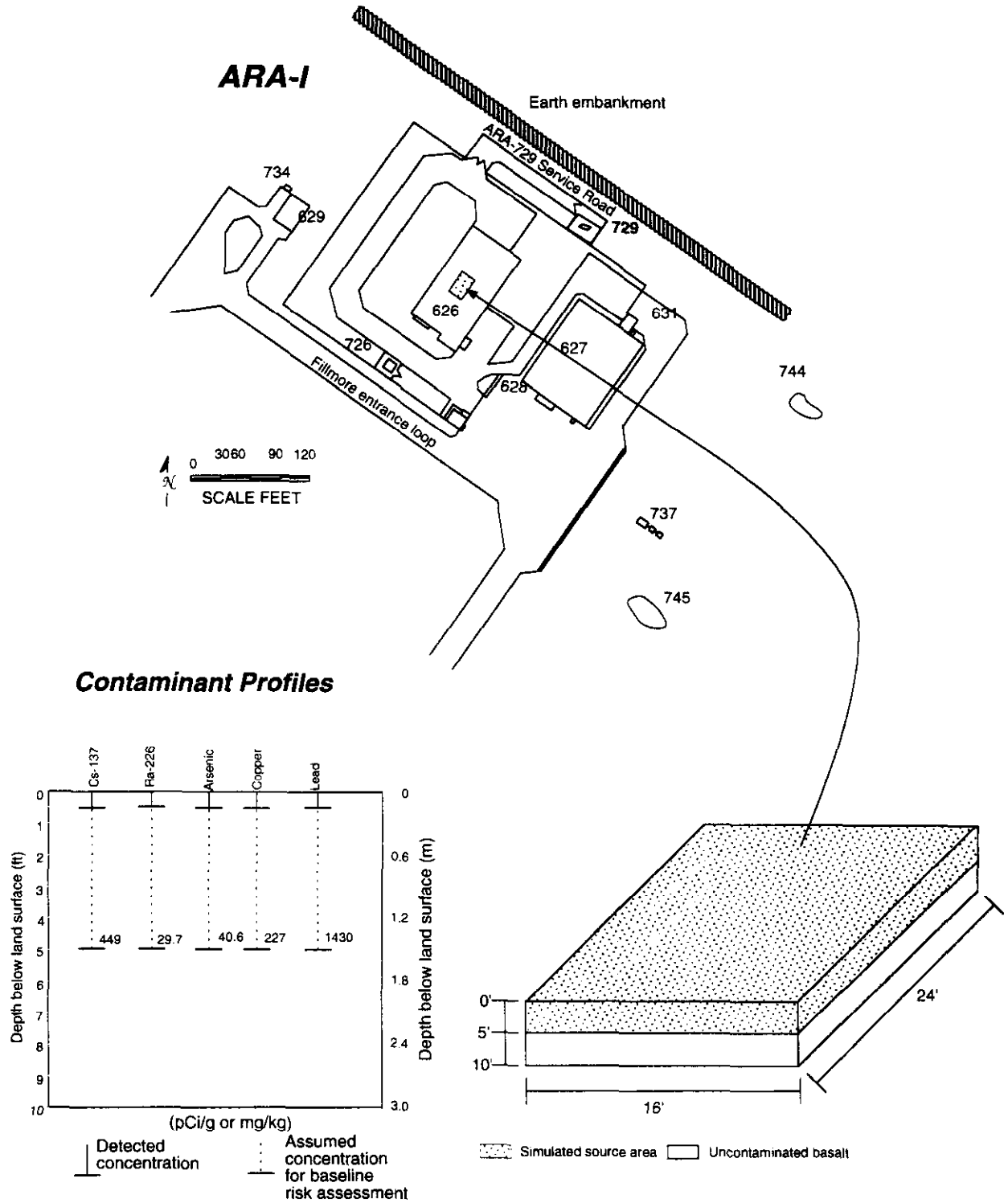

Figure 18. Site ARA-25, ARA-I contaminated soil beneath the ARA-626 hot cells.

In the three soil samples, the ranges of contaminant concentrations are 3.6 to 40.6 mg/kg compared to a background concentration of 5.8 mg/kg for arsenic, 115 to 227 mg/kg compared to a background value of 22 mg/kg for copper, 3.5 to 1,430 mg/kg for lead compared to a background value of 17 mg/kg, 226 to 449 pCi/g compared to a background value of 0.8 pCi/g for Cs-137, and 5.4 to 29.7 pCi/g for Ra-226 compared to a background value of 2.1 pCi/g (Giles 1998a). Background concentrations for arsenic, copper, lead, and Cs-137 were taken from Rood, Harris, and White (1996).

8.4.3 Summary of Site Risks

The analytical results showed concentrations of arsenic, lead, Co-60, Cs-134, Cs-137, Eu-152, Eu-154, Ra-226, and Sr-90 in excess of human health screening levels in the soil. Arsenic, chromium, cobalt, and copper were detected in concentrations above ecological screening levels. Therefore, the site was retained for quantitative risk assessment in the WAG 5 comprehensive BRA (Holdren et al. 1999). The human health and ecological risk assessments are summarized below.

8.4.3.1 Human Health Risk Assessment. Arsenic, lead, Cs-137, and Ra-226 were identified as COCs for ARA-25 based on human health risk estimates. A summary of the information about the human health COCs in soil at ARA-25 is given in Table 13.

Table 13. Soil concentrations for the contaminants of concern at ARA-25.

Contaminant of Concern	Half-life (years)	Minimum Concentration (pCi/g or mg/kg)	Maximum Concentration (pCi/g or mg/kg)	Frequency of Detection	Background Concentration (pCi/g or mg/kg)	Exposure Point Concentration (pCi/g or mg/kg)	Statistical Measure[a]
Cs-137	30	226	449	3/3	0.82[b]	449	Maximum
Ra-226	1,600	14.3	29.7	2/3	1.2 or 2.1[c]	29.7	Maximum
Arsenic	NA	8.98	40.6	3/3	5.8	40.6	Maximum
Lead	NA	3.54	1,430	3/3	17	1,430	Maximum

a. The number of samples was too small for statistical analysis (i.e., calculation of 95% upper confidence limits on the means). Therefore, the maximum detected concentrations were used for the exposure point concentrations.

b. The background value for composited samples is from Rood, Harris, and White (1996).

c. The average INEEL background concentration is 1.2 pCi/g for analysis that accounts for U-235 and 2.1 pCi/g to include interference from U-235 (Giles 1998a).

The total estimated risk for all pathways for the 100-year future residential scenario for the soil under the hot cells is 7E-03 (7 in 1,000), with the major contributors to the risk being 5E-03 (5 in 1,000) from Ra-226, 2E-03 (2 in 1,000) from Cs-137, and 4E-04 (4 in 10,000) from arsenic. The noncarcinogenic HQ for residential exposure is 3.0, and arsenic is the only contributor.

The total estimated risk for all pathways for the current occupational scenario is 5E-03 (5 in 1,000). The major contributors are 4E-03 (4 in 1,000) from Cs-137, 1E-03 (1 in 1,000) from Ra-226, and 1E-04 (1 in 10,000) from arsenic. The hazard index for the current occupational exposure is less than 1.0.

The total estimated risk for all pathways for the 100-year future occupational scenario is 2E-03 (2 in 1,000). The primary contributions are 1E-03 (1 in 1,000) from Ra-226, 4E-04 (4 in 10,000) from Cs-137, and 1E-04 (1 in 10,000) from arsenic. The noncarcinogenic hazard index for the future occupational exposure is less than 1.0.

The risks from lead could not be quantified in the human health risk assessment because toxicity data for lead are not available. However, the maximum concentration of lead detected at ARA-25, 1,430 mg/kg, exceeds the EPA 400 mg/kg screening level (EPA 1994b). Therefore, lead is identified as a COC and will be targeted during remediation.

8.4.3.2 Ecological Risk Assessment. Copper and lead were identified as COCs for ARA-25 based on the results of the ERA. A summary of the information about the ecological COCs in soil at ARA-25 is given in Table 14.

Table 14. Soil concentrations for the ecological contaminants of concern at ARA-25.

Contaminant of Concern	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Frequency of Detection	Background Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	Statistical Measure[a]
Copper	115	227	3/3	22[b]	227	Maximum
Lead	3.54	1,430	3/3	17[b]	1,430	Maximum

a. The number of samples was too small for statistical analysis (i.e., calculation of 95% upper confidence limits on the means). Therefore, the maximum detected concentrations were used for the exposure point concentrations.

b. The background value for composited samples is from Rood, Harris, and White (1996).

The HQs for copper at ARA-25 range from less than or equal to 1 to 5 for avian insectivores (AV210A, AV221, AV222, AV222A), 3 to 10 for mammalian herbivores including the pygmy rabbit (M121, M122, M122A, M123) and less than or equal to1 to 40 for mammalian insectivores (including an HQ of 2 for all bats). The HQ is 4 for mammalian omnivores (M422). No TRV data are available to assess reptilian receptors (R222, R322).

The HQs for lead at ARA-25 range from 2 to 30 for avian herbivores (AV121, AV122) and from 20 to 900 for avian insectivores (AV210A, AV221, AV222, AV222A). The HQs range from less than or equal to 1 to 4 for mammalian herbivores (M121, M122, M122A, M123), including an HQ of 1 for the pygmy rabbit, and from less than or equal to 1 to 20 for mammalian insectivores (including an HQ of less than or equal to 1 for bats). The HQs are from less than or equal to 1 to 3 for mammalian omnivores (M422, M422A). The HQ for lead for plants is 1. No TRV data are available to assess reptilian receptors (R222, R322).

8.5 Site PBF-16: SPERT-II Leach Pond

Remedial action is required for the PBF-16 SPERT-II Leach Pond to address the risk to ecological receptors posed by contaminated soil. Site investigations, the nature and extent of contamination, and a summary of site risks are presented below. More detailed information about the pond can be found in the WAG 5 Comprehensive RI/FS report (Holdren et al. 1999).

The PBF-16 site is a fenced, unlined surface impoundment, with approximate dimensions of 70 × 51 m (230 × 167 ft), located south of the SPERT-II Reactor Building. From 1959 to 1964, the leach pond was used for disposal of demineralizer effluent, water softener waste, emergency shower drain water, and discharges from the floor drains from the reactor building. From 1964 until 1990, the only discharge to the pond was clean water from the PBF maintenance shop air compressor (Hillman-Mason et al. 1994). The compressor was removed in 1994 and no water has been discharged to the SPERT-II

Leach Pond for several years (Gerber 1999). An aerial photograph of the PBF-16 was not available. A sketch of the PBF-16 pond relative to an aerial photograph of the Waste Engineering Development Facility (i.e., SPERT-II) is shown in Figure 19.

8.5.1 Site Investigations

The SPERT-II leach pond was sampled in 1982 and again in 1983. The 1982 characterization (EG&G 1982) consisted of collecting 18 soil samples, two water samples, and several vegetation samples. All samples were analyzed for radionuclides. The radioactivity levels were within background values. The pond was sampled again in 1983 to determine the presence and concentrations of hazardous substances. Lead and mercury were detected in concentrations exceeding background values with maximum concentrations of 32 mg/kg for lead and 0.71 mg/kg for mercury (Hillman-Mason et al. 1994). No sampling data gaps were identified in the WAG 5 Work Plan (DOE-ID 1997a). Therefore, no additional samples of the pond were collected. The site was evaluated in the WAG 5 Comprehensive RI/FS using the data collected in 1982 and 1983.

8.5.2 Nature and Extent of Contamination

The soil profile for mercury and the source volume used in the risk assessment and the location of PBF-16, the SPERT-II Leach Pond, relative to the Waste Engineering Development Facility, are illustrated in Figure 20. The maximum detected mercury concentration of 0.71 mg/kg was assumed for the entire soil interval to a depth of 10 ft. The background concentration at the INEEL for composited mercury samples is 0.05 mg/kg (Rood, Harris, and White 1996).

8.5.3 Summary of Site Risks

The SPERT-II Leach Pond was screened from evaluation in the human health risk assessment (Holdren et al. 1999). Mercury was detected at 0.71 mg/kg and eliminated from evaluation based on comparison to the risk-based soil concentration of 23 mg/kg (EPA 1995). Though lead was detected at 32 mg/kg, risk could not be quantified because toxicity data for lead have not been developed. However, the maximum detected lead concentration is considerably less than the EPA 400-mg/kg screening level (EPA 1994b). Therefore, lead was not identified as a COC based on human health risk.

Mercury was identified as a COC for PBF-16 based on the results of the ERA (Holdren et al. 1999). The HQs for mercury range up to 50 for mammalian insectivores at PBF-16. Avian and mammalian herbivores have HQs that exceed 1.0 including an HQ of 10 for the pygmy rabbit. Because HQs that exceed 10 are associated with the site, remediation will be implemented to protect ecological receptors. A summary of the information about the COC in soil at PBF-16 is given in Table 15.

Table 15. Soil concentrations for the contaminant of concern at PBF-16.

Contaminant of Concern	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Frequency of Detection	Background Concentration (mg/kg)	Exposure Point Concentration (mg/kg)	Statistical Measure
Mercury	ND[a]	0.71	ND	0.05[b]	0.71	Maximum

a. ND = not determined. Records of the 1983 sampling by decontamination and dismantlement personnel were not located. The maximum concentration was taken from the Track 2 report (Hillman-Mason et al. 1994).

b. The background value for composited samples is from Rood, Harris, and White (1996).